DOCUMENT RESUME

ED 158 142 CE 017 792

TITLE	Petroleum Refining, Industrial Chemical, Drug, and Paper and Allied Products Industries. Reprinted from the Occupational Outlook Handbook, 1978-79 Edition.
INSTITUTION	Bureau of Labor Statistics (DOL), Washington, D.C.
REPORT NO	Bull-1955-38
PUB DATE	78
NOTE	21p.; Photographs in this document will not reproduce well; For related documents see CE 017 756-797
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 ($0.50 per reprint; $8.00 for set of 42)
EDRS PRICE	MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS	*Chemical Industry; Employment Opportunities; *Employment Projections; *Employment Qualifications; Employment Trends; Industrial Personnel; Information Sources; Job Skills; Job Training; Manufacturing Industry; *Occupational Information; Occupational Mobility; *Paper (Material); *Petroleum Industry; Promotion (Occupational); Salaries; Wages; Work Environment
IDENTIFIERS	*Drug Industry

ABSTRACT

Focusing on occupations in refining and industrial chemical, drug, and paper manufacturing industries, this document is one in a series of forty-one reprints from the Occupational Outlook Handbook providing current information and employment projections for individual occupations and industries through 1985. The specific occupations covered in this document include occupations in the drug industry, occupations in the industrial chemical industry, occupations in the paper and allied products industries, and occupations in the petroleum refining industry. The following information is presented for each occupation or occupational area: a code number referenced to the Dictionary of Occupational Titles; a description of the nature of the work; places of employment; training, other qualifications, and advancement; employment outlook; earnings and working conditions; and sources of additional information. In addition to the forty-one reprints covering individual occupations or occupational areas (CE 017 757-797), a companion document (CE 017 756) presents employment projections for the total labor market and discusses the relationship between job prospects and education. (BM)

Petroleum Refining, Industrial Chemical, Drug, and Paper and Allied Products Industries

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Occupational Outlook Handbook,
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U.S. Department of Labor
Bureau of Labor Statistics
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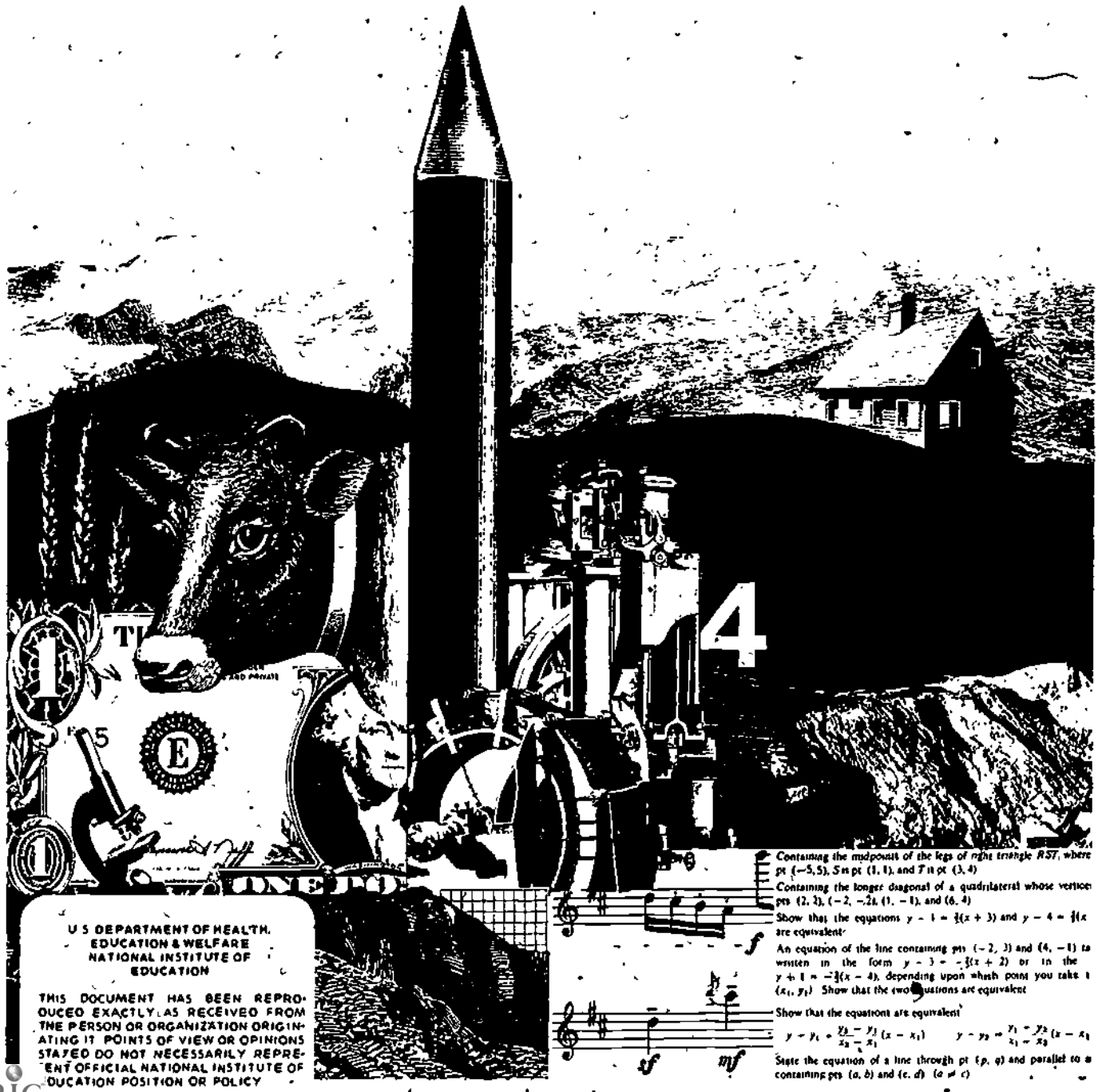
Bulletin 1955-38



Containing the midpoints of the legs of right triangle *RST*, where pt (−5, 5), *S* is pt (1, 1), and *T* is pt (3, 4)

Containing the longer diagonal of a quadrilateral whose vertices pts (2, 3), (−2, −2), (1, −1), and (6, 4)

Show that the equations $y - 1 = \frac{1}{2}(x + 3)$ and $y - 4 = \frac{1}{2}(x$ are equivalent.

An equation of the line containing pts (−2, 3) and (4, −1) is written in the form $y - 3 = -\frac{2}{3}(x + 2)$ or in the $y + 1 = -\frac{2}{3}(x - 4)$, depending upon which point you take (x_1, y_1). Show that the two equations are equivalent.

Show that the equations are equivalent.

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1) \qquad y - y_2 = \frac{y_1 - y_2}{x_1 - x_2}(x - x_2)$$

State the equation of a line through pt (*p*, *q*) and parallel to a containing pts (*a*, *b*) and (*c*, *d*) ($a \neq c$).

OCCUPATIONS IN THE DRUG INDUSTRY

References to potions and spells for the cure and prevention of pain and disease are numerous in medical folklore But 20th century science has created a supply of drug products undreamed of by even the most imaginative apothecaries of the past.

More than 10,000 individual or combination drug products are available to today's physician for diagnostic, preventive, and therapeutic uses. These drugs have resulted in the control of venereal disease, tuberculosis, influenza, cardiovascular disease, malaria, pneumonia, and even some forms of cancer. Hormones have relieved the pain and crippling effects of arthritis and other diseases. Tranquilizers and other drugs have done much to reduce the severity of mental illness. Vaccines have reduced dramatically the toll of polio, whooping cough, and measles. Discoveries in veterinary medicine have increased animal productivity and controlled various diseases, some of which are transmissible to humans. New drugs which control symptoms of various diseases and disorders have resulted in remarkable benefits to society by increasing life expectancy and allowing many ill people to lead full and reasonably normal lives.

The American drug industry has achieved worldwide prominence through its activities in research and development of new drugs, and spends a higher proportion of its funds for research than any other industry in the United States. About 80 percent of research and development expenditures is devoted to the advancement of scientific knowledge and the development of new products. The remaining funds are allocated to the improvement of existing products. Each year the industry tests more than 150,000 new substances which may eventually yield only 10 to 20 completely new, useful medicines. In recent years, most research has been devoted to infections, diseases of the central nervous and cardiovascular systems, and to neoplasm therapy (treatment of abnormal tissue growth).

Drug firms also are involved in research and the development of other types of products and chemicals. Closely related to drugs as important adjuncts to modern medical care are medical devices and diagnostic products Many pharmaceutical as well as other manufacturers in the past few years have entered the fast growing production of radiological equipment, radio-pharmaceuticals, heart pacemakers, dialysis machines, and numerous other products. These are used to diagnose disease on one hand or, like drugs, help alleviate symptoms and restore health and well-being. Many firms also are involved in the agricultural chemical market. Many of the same types of employees required in the research and quality control-oriented production of human and animal-use drugs also are required in these other areas.

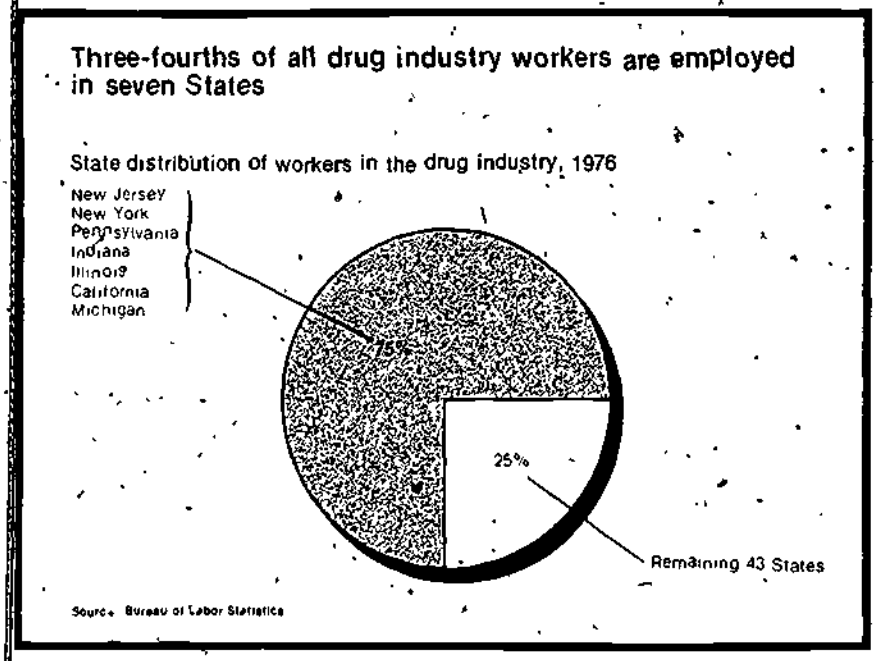
Nature and Location of the Industry

In 1976, about 165,000 persons worked in the drug industry. Over 130,000 worked for companies that made pharmaceutical preparations (finished drugs), such as tranquilizers, antiseptics, antibiotics, and analgesics. The remainder worked for firms that made biological products, such as serums, vaccines, toxins, plasmas, and bulk medicinal chemicals and botanicals used in making finished drugs.

Drug manufacturing companies typically employ large numbers of workers. About two-thirds of the industry's employees work for firms with more than 500 workers; over one half work for firms employing over 1,000 workers. Some of the largest firms employ more than 5,000 workers. The Pharmaceutical Manufacturers Association (PMA) represents about 130 companies that produce most of the Nation's pharmaceuticals, accounting for over 90 percent of total drug sales.

About three-fourths of the industry's employees worked in seven States: New Jersey, New York, Pennsylvania, Indiana, Illinois, California, and Michigan. Large drug manufacturing installations are located in Indianapolis, Ind.; Chicago, Ill.; Nutley and Rahway, N.J.; Philadelphia, Pa.; Kalamazoo, Mich.; Pearl River and Brooklyn, N.Y.; and in the Los Angeles and San Francisco, Calif., areas.

For testing new drugs, a primary research method called screening is used In screening an antibiotic, for example, a sample is first placed in a bacterial culture. If the antibiotic is effective, it is next tested on infected laboratory animals. Each year research personnel study the effects of potential new medicines on millions



of animals including mice, rats, chickens, and guinea pigs. Promising compounds are studied further for evidence of useful—and harmful—effects. A new drug is selected for testing in humans only if it promises to have therapeutic advantages over comparable drugs already in use, or if it offers the possibility of being safer.

After laboratory screening, a clinical investigation, or trial of the drug on human patients, is made. Supplies of the drug are given to a small group of doctors who administer it to carefully selected consenting patients. The patients are then observed closely and special studies made to determine the drug's effect. If a drug proves useful, arrangements are made for more tests with a larger group of physicians.

Once a drug has successfully passed animal and clinical tests, problems of production methods and costs must be worked out before manufacturing begins. If the original laboratory process of preparing and compounding the ingredients is complex and expensive, pharmacists, chemists, chemical engineers, packaging engineers, and production specialists are assigned to develop processes economically adaptable to mass production.

Drug manufacturers have developed a high degree of automation in many production operations. Milling and micronizing machines (which pulverize substances into extremely fine particles) are used to reduce bulk chemicals to the required size. These finished chemicals are combined and processed further in mixing machines. The mixed ingredients may then be mechanically capsulized, pressed into tablets, or made into solutions. One type of machine, for example, automatically fills, seals, and stamps capsules. Other machines fill bottles with capsules, tablets, or liquids, and seal, label, and package the bottles.

Quality assurance or control is vital in this industry. A quality control system involves selection and training of personnel; product design; establishment of specifications, procedures, and tests; design and maintenance of facilities and equipment, selection of materials; and recordkeeping. In an effective system, all these aspects of quality control are evaluated on a regular basis, and modified and improved when appropriate. Quality-conscious manufacturers may assign one of every six production workers to quality assurance functions alone, while all other employees may devote part of their time to these functions. For example, although pharmaceutical company representatives called detailers primarily work in marketing, they engage in quality control when they assist pharmacists in checking for outdated products.

A drug may undergo hundreds of complex, time-consuming quality control checks at various stages during the manufacturing process to insure that it conforms to specifications. Although some inspection operations are mechanized, many are performed manually.

The pharmaceutical industry is closely regulated. The Food and Drug Administration (FDA) has legal authority to inspect manufacturing plants, test drugs and examine drug imports, and monitor drug research, testing, development, marketing, and consumption.

Occupations in the Industry

Employees with many different levels of skill and education work in the drug industry. About half are in white-collar jobs (scientific, technical, administrative, clerical, and sales), a much higher proportion than in most other manufacturing industries; the other half are in plant jobs (processing or production, maintenance, transportation, and service).

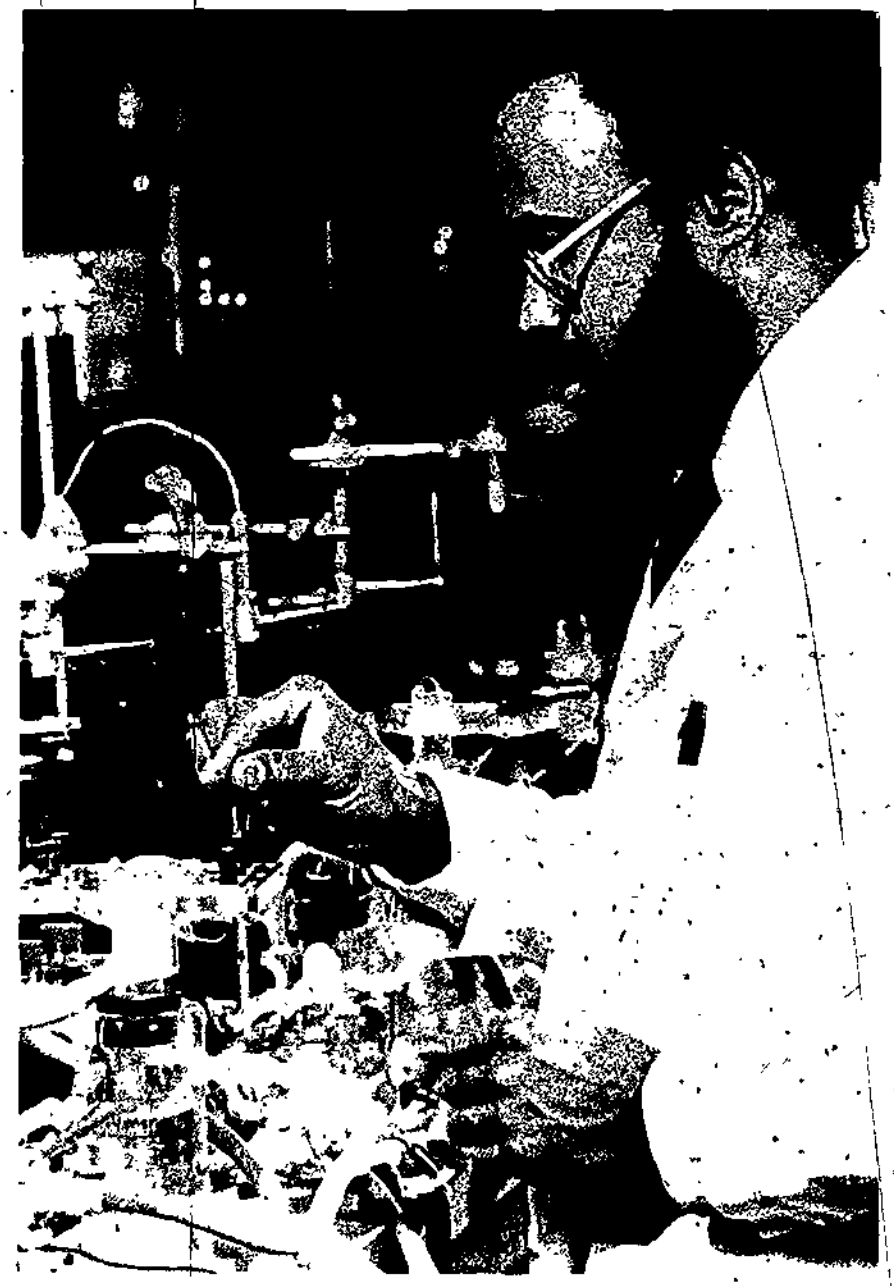
Some of the important occupations are described briefly below. Detailed discussions of professional, technical, clerical, and other occupations found in drug manufacturing, as well as in other industries, are given elsewhere in the *Handbook*.

Scientific and Technical Occupations. About one out of every six employees in the industry is a scientist, engineer, or technician—a far greater proportion than in most other industries. The majority do research to develop new drug products. Others work to streamline production methods and improve environmental and quality control.

About 1 out of every 6 employees in the drug industry is a scientist, engineer, or technician.

Chemists (D O T 022 081) make up the largest group of scientific and technical personnel in the industry Organic chemists combine new compounds for biological testing Physical chemists separate and identify substances, determine molecular structure, help to create new compounds, and improve manufacturing processes. Biochemists study the action of drugs on body processes. Radiochemists trace the course of drugs through body organs and tissues. Pharmaceutical chemists set standards and specifications for the form of products and for storage conditions and see that labeling and literature meet the requirements of State and Federal laws. Analytical chemists test raw and intermediate materials and finished products for quality.

Several thousand *biological scientists* (D.O.T. 041.081, .181) work in the drug industry. Biologists and bacteriologists study the effect of chemical agents on infected animals. Microbiologists grow strains of microorganisms which produce antibiotics. Physiologists investigate the effect of drugs on body functions and vital processes. Pharmacologists and zoologists study the effect of drugs on animals. Virologists grow viruses, develop vaccines, and test them in animals. Botanists, with their special knowledge of plant life, contribute to the discovery of botanical ingredients for drugs. Other biological scientists include pathologists, who study normal and abnormal cells or tissues, and toxicologists, who are concerned with the safety, dosage levels, and the compatibility of different drugs. Pharmacists perform research in product development, studying many forms of medicines at various stages of production. Some set specifications for the purchase and manufacture of materials, and handle correspondence relating to products. Drug manufacturers also employ physicians and veterinarians.



Biologist conducts tests that monitor the effect of different compounds on heart muscle.

Engineers account for a small fraction of scientific and technical workers, but make significant contributions toward improving quality control and production efficiency. *Chemical engineers* (D.O.T. 008.081) design equipment and devise manufacturing processes. *Industrial engineers* (D.O.T. 012.081, .168, .187, .188, and .281) plan equipment layout and workflow to maintain efficient use of plant facilities. *Mechanical engineers* (D.O.T. 007.081, .151, .181, and .187) coordinate the installation and maintenance of sterilizing, heating, cooling, humidifying, and ventilating equipment.

Technicians (D.O.T. 073.381, 078.128, .168, .281, .381, and .687) represent about one-third of the drug industry's scientific and technical workers. Laboratory tests play an important part in the detection and diagnosis of disease and in the discovery of medicines. Laboratory technicians perform these tests under the direction of scientists in such areas as bacteriology, biochemistry, microbiology, virology (the study of viruses), and cytology (analysis of cells).

Administrative, Clerical, and Related Occupations. About 1 out of every 3 workers in drug manufacturing is in

an administrative, clerical, or other office job. At the top of the administrative group are the executives who make policy decisions concerning matters of finance, marketing, and research. Other administrative and executive workers include accountants, lawyers, purchasing agents, personnel and labor relations workers, public relations workers, economists, technical writers, computer specialists, and advertising and marketing research workers. Clerical employees include secretaries, typists, office machine operators, and others who keep records on personnel, payroll, raw materials, sales, shipments, and plant maintenance.

Pharmaceutical detailers (D.O.T. 266.158), often called pharmaceutical sales representatives, describe their companies' products to physicians, pharmacists, dentists, and health services administrators, and serve as lines of communication between their companies and clients.

Plant Occupations. Nearly half of the industry's employees work in plant jobs. The majority of these workers can be divided into three major occupational groups: production or processing workers, who operate the drug-producing equipment; maintenance workers, who install, maintain, and repair this equipment; and shipping clerks, truckdrivers, and material handlers, who help transport the drugs.

Various types of chemical operators are involved in the production of pharmaceutical preparations and biological products. *Pharmaceutical operators* (D.O.T. 559.782) control machines that produce tablets, capsules, ointments, and medicinal solutions. *Granulator machine operators* (D.O.T. 559.782) tend milling and grinding machines that reduce mixtures to particles of designated sizes. *Compounders* (D.O.T. 550.885) tend tanks and kettles in which solutions are mixed and compounded to make up creams, ointments, liquid medications, and powders. *Compressors* (D.O.T. 556.782) operate machines that compress ingredients into tablets. *Pill and tablet coaters* (D.O.T. 554.782), often called capsule coaters, control a battery of machines that apply coatings to tablets which flavor, color, preserve, add medication, or control disintegration time. *Tablet testers* (D.O.T. 559.687) inspect tablets for hardness, chippage, and weight to assure conformity with specifications.

Ampoule fillers (D.O.T. 559.885) operate machines that fill small glass containers with measured doses of liquid drug products. *Ampoule examiners* (D.O.T. 559.687) examine the ampoules for discoloration, foreign particles, and flaws in the glass.

After the drug product is prepared and inspected, it is bottled or packaged. Most of the packaging and bottle filling jobs are done by semiskilled workers who operate machines that measure exact amounts of the product and seal containers.

The drug industry employs many skilled maintenance workers to assure that production equipment is operating properly and to prevent costly breakdowns. Included among maintenance workers are powerplant operators who are responsible for high pressure boilers, turbogenerators, compressors, refrigeration equipment, and plant water systems; electricians who install, maintain, and repair the various types of electrical equipment; plumbers who install and maintain heating, plumbing, and pumping systems; machinists who make and repair metal parts for machines and equipment; and instrument repairers who periodically inspect instruments and controls and repair or replace malfunctioning parts. Drug firms also employ pipefitters, millwrights, and many other skilled workers.

Plant workers who do not operate or maintain equipment perform a variety of other tasks. Some drive trucks to make deliveries to other parts of the plant; some load and unload trucks and railroad cars; others keep inventory records. The industry also employs service workers, such as guards, cooks, and janitors, whose duties are similar to those of such workers in other industries.

Training, Other Qualifications, and Advancement

Training requirements for jobs in the drug industry range from a few hours of on-the-job training to years of formal educational preparation plus job experience. Because quality control is of paramount importance, the drug industry places a heavy emphasis on continuing education for employees, and many firms provide classroom training in safety, environmental and quality controls, and other areas.

For production and maintenance occupations, drug manufacturers generally hire inexperienced workers and train them on the job; high school graduation is not essential but generally is preferred by most firms. Beginners in production jobs assist experienced workers and learn the operation of the processing equipment. With experience, employees may advance to more skilled jobs in their departments. Most maintenance jobs are filled by people who start as helpers to electricians, plumbers, machinists, and other craft workers.

Many companies encourage production and maintenance workers to take courses related to their jobs in local schools and technical institutes, or to enroll in correspondence courses. College courses in chemistry and related areas are particularly encouraged for highly skilled production workers who operate sophisticated equipment. Some companies reimburse the workers for part, or all, of the tuition. Skilled production and maintenance workers with leadership ability may advance to supervisory positions.

For technicians in the drug industry, methods of qualifying for jobs vary in many ways. Some technicians enter the field with a high school education and advance to jobs of greater responsibility with experience and additional formal education. However, companies increasingly prefer to hire graduates of technical institutes or junior colleges, or those who have completed college courses in chemistry, biology, mathematics, or engineering. In many firms, newly hired workers begin as laboratory helpers or aides, performing routine jobs such as cleaning and arranging bottles, test tubes, and other equipment.

The experience required for higher levels of technician jobs varies from company to company. Generally,

employees advance over a number of years from assistant technician, to technician, to senior technician, to technical associate. Some companies require senior technicians and technical associates to complete job-related college courses.

For most scientific and engineering jobs, a bachelor of science degree is the minimum requirement. Some companies have formal training programs for college graduates with engineering and scientific backgrounds. These trainees work for brief periods in the various divisions of the plant to gain a broad knowledge of drug manufacturing operations before being assigned to a particular department. In other firms, newly employed scientists and engineers are immediately assigned to a specific activity such as research, process development, production, or sales. Drug manufacturing companies prefer to hire college graduates, particularly those with strong scientific backgounds, as pharmaceutical detailers. Newly employed pharmaceutical representatives complete rigorous formal training programs revolving around their companies' product lines.

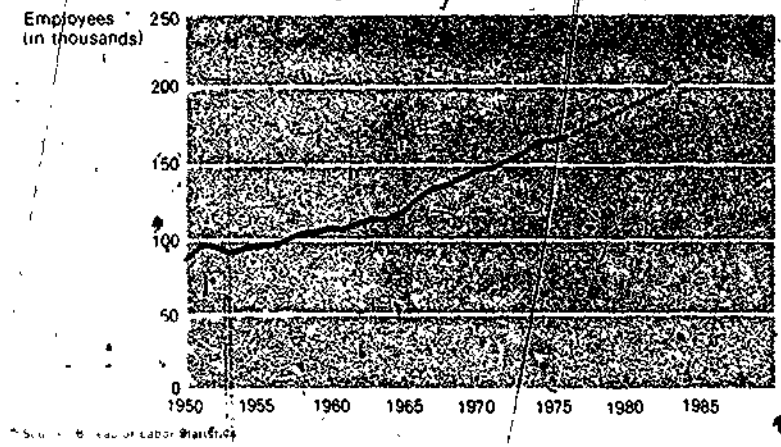
Job prospects and advancement usually are best for professionals with advanced degrees. Over half of all professionals involved in research and development have a doctoral or master's degree. Some companies offer training programs to help scientists and engineers keep abreast of new developments in their fields and to develop administrative skills. These programs may include meetings and seminars with consultants from various fields. Many companies encourage scientists and engineers to further their education, some provide financial assistance for this purpose. Publication of scientific papers also is encouraged.

Employment Outlook

Drug manufacturing employment is expected to grow about as fast as the average for all industries through the mid-1980's. In addition to employment growth, many job openings will result from deaths, retirements, and other separations from the labor force.

Drug industry employment has shown fairly steady growth

Wage and salary workers in the drug industry, 1950-76 and projected 1985



The demand for drug products is expected to grow very rapidly. Demand will be stimulated primarily by population growth, particularly the growing number of older people who require more health care services, and by the growth of public and private health insurance programs, which generally cover the cost of drugs and medicine. Adoption of a national health insurance program could further expand the market for drugs. Other factors that are expected to increase the demand for drugs include greater personal income, the rising health consciousness of the general public, and the discovery of new drugs. A continued rise in foreign drug sales, particularly to developing countries with mounting health care requirements, also is anticipated.

The industry's employment will not increase as rapidly as the demand for drug products, however, because technological improvements in production methods will increase output per worker. The more widespread use of automatic processing and control equipment in operations formerly done by hand will tend to reduce labor requirements, particularly in plants where common drugs are mass-produced. For example, mixing and granulating processes, which precede tableting, have become completely mechanized in some plants. In addition, computers increasingly are used in quality control systems to eliminate computational errors in analysis and testing and to speed up production and shipment. Computers, thus, have tended to take over some of the tasks of professional, technical, and production workers.

The rate of employment growth over the last few decades is not expected to continue. Only moderate increases are anticipated in the number of scientists, engineers, and technicians engaged in pharmaceutical research and development. Increasingly restrictive government regulations have reduced the rate of return on investment in research and development, and, as a result, drug manufacturers are expected to limit future expansion in this area. Demand for skilled maintenance workers (such as electricians, machinists, plumbers, and instrument repairers) will be spurred by the need to service the growing amount of automatic processing and control equipment. Employment of administrative and clerical workers is expected to increase moderately. Demand for laborers and many semiskilled plant occupations is not expected to increase significantly, as more processes are adapted to automatic equipment. However, demand for highly skilled production workers to operate the

increasingly sophisticated equipment used in drug manufacturing is expected to rise.

Unlike many other manufacturing industries, drug industry employment is not highly sensitive to changes in economic conditions. Thus, even during periods of high unemployment, work is likely to be relatively stable in the drug industry.

Earnings and Working Conditions

Earnings of plant workers in the drug industry are higher than the average for all manufacturing industries. For example, in 1976, production workers in the drug industry averaged $5.50 an hour, while those in manufacturing as a whole averaged $5.19 an hour.

According to a 1973 Bureau of Labor Statistics Survey, earnings of office employees in the drug manufacturing industry were 68 percent higher than earnings for production workers. Earnings generally were highest in the North Central Region and lowest in the South. Employees generally received bonuses, vacation and sick leave, paid holidays, life, health, and accident insurance, workers' compensation, and retirement plans.

National wage data are not available for individual occupations in the drug industry. However, statements on specific occupations, such as chemist, pharmacist, and technician, found in other parts of the *Handbook*, will give general earnings information.

Some employees work in plants that operate around the clock—3 shifts a day, 7 days a week. In most plants, workers receive extra pay when assigned to second or third shifts. Since drug production is subject to little seasonal variation, work is steady.

Working conditions in drug plants are better than in most other manufacturing plants. Much emphasis is placed on keeping equipment and work areas clean because of the danger of contamination of drugs. Plants usually are air-conditioned, well-lighted, and quiet. Ventilation systems protect workers from dust, fumes, and disagreeable odors. Special precautions are taken to protect the relatively small number of employees who work with infectious cultures and poisonous chemicals. With the exception of work performed by material handlers and maintenance workers, most jobs require little physical effort. The frequency and severity of injuries in drug manufacturing has been about half the average for all manufacturing industries.

Some of the industry's production and maintenance employees are members of labor unions. The principal unions in the industry are the Oil, Chemical and Atomic Workers International Union, the International Chemical Workers Union, and United Steel Workers of America.

Sources of Additional Information

For additonal information about careers in drug manufacturing and the industry in general, write to the personnel departments of individual drug manufacturing companies and to:

Pharmaceutical Manufacturers Association, 1155 Fifteenth St NW, Washington, D.C. 20005

OCCUPATIONS IN THE INDUSTRIAL CHEMICAL INDUSTRY

Industrial chemical products are the raw materials for all kinds of everyday items, from nylon stockings to automobile tires. Chemicals also are used to treat drinking water, to propel rockets, and to make steel, glass, explosives, and thousands of other items. The discovery of nylon, plastics, and other new products has helped the industrial chemical industry become one of the Nation's most important.

Making these many, very different kinds of products requires a large number of workers with many different skills. About 540,000 people in many different occupations worked in the industrial chemical industry in 1976. Training varies from a few days on the job for some plant workers to college degrees for engineers and chemists.

Nature of the Industry

The industry produces organic and inorganic chemicals, plastics, and synthetic rubber and fibers. Unlike drugs, paints, and other chemical products sold directly to consumers, industrial chemicals are used by other industries to make their own products.

Chemical products are made from coal, petroleum, limestone, mineral ores, and many other raw materials. Since these materials usually go through several chemical changes, the finished products are vastly different from the original ingredients. Some plastics, for example, are made from natural gas.

In a modern chemical plant, electronic and other automated equipment controls the dissolving, heating, cooling, mixing, filtering, and drying processes that convert raw materials to finished products. This equipment regulates the combination of ingredients, flow of materials, and the temperature, pressure, and processing time. Materials also are moved automatically from one part of the plant to another by conveyors or through pipes. Through the use of such automated equipment, a relatively small number of workers can produce tons of chemicals in one continuous operation.

About two-thirds of the 3,000 industrial chemical plants in the United States have fewer than 50 workers. Over half of the industry's employees, however, are concentrated in large plants with more than 500 workers.

Chemical plants are usually close to manufacturing centers or near the sources of raw material. Many plants that produce chemicals from petroleum, for example, are near the oil fields of Texas and Louisiana. Al-

though industrial chemical workers are employed in almost every State, about half of them work in Tennessee, New Jersey, Texas, Virginia, West Virginia, Ohio, and South Carolina.

Occupations in the Industry

Workers with many different skills and levels of education work in the industrial chemical industry. Research scientists, engineers, and technicians develop products and design equipment and production processes. Administrators, professionals, and clerical workers handle financial and business matters, keep records, and advertise and sell chemical products. Other employees are in processing, maintenance, and other plant jobs.

Scientific and Technical Occupations. The industrial chemical industry is one of the Nation's major employers of scientific and technical workers. 1 out of 5 of its employees is a scientist, engineer, or technician. An even larger number are administrators or production supervisors. Because the sale of chemical products frequently requires a technical background, scientists and engineers may take jobs as sales representatives.

Chemists are the largest and one of the most important group of scientists in the industry. Through basic and applied research, chemists learn about the properties of chemicals in order to find new and improved products and production methods. Their efforts have led to the discovery of plastics, nylon, and many other items.

Chemists also work in activities other than research and development. A large number supervise plant workers or analyze and test chemical samples to insure the quality of the final product. Many are administrators, marketing experts, chemical sales workers, and technical writers.

Engineers are another important group of industrial chemical professionals. Using their knowledge of both chemistry and engineering, chemical engineers convert laboratory processes into large-scale production methods. They design chemical plants and processing equipment and sometimes supervise their construction and operation. Chemical engineers also fill jobs in sales, customer service, market research, plant management, and technical writing.

Mechanical engineers design power and heating equipment. They also work with chemical engineers to design processing equipment and supervise its installation, operation, and maintenance. Electrical engineers design electric and electronic instruments and control devices, and facilities for generating and distributing electric power

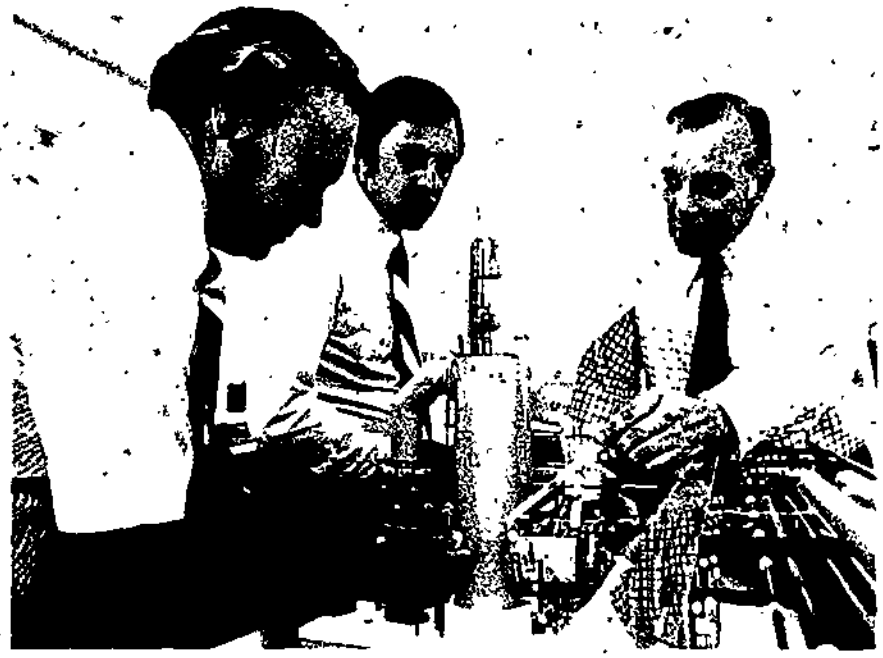
Many technical workers assist scientists and engineers Laboratory technicians conduct tests and record the results in charts, graphs, and reports that are used by chemists and chemical engineers. Their work may range from simple routine tests to complicated analyses. Drafters provide engineers with specifications and detailed drawings of chemical equipment.

Plant Occupations. About three out of every five industrial chemical workers operate or maintain equipment or do other plant jobs.

Skilled *chemical operators* (D.O.T. 558.885 and 559.782) and their helpers are the largest group of plant workers. They set dials, valves, and other controls on automatic equipment to insure that the right temperature, pressure, and amounts of materials are used. As chemicals are processed, operators read instruments that measure pressure, flow of materials, and other conditions. They also use instruments to test chemicals or send chemical samples to the testing laboratory. Operators keep records of instrument readings and test results and report equipment breakdowns. Chemical operators sometimes are called filterers, mixers, or some other title, depending on the kinds of equipment they operate.

To keep production processes running smoothly, instruments must give accurate measurements and equipment must withstand corrosion, damaging chemicals, high temperatures, and pressure. Many skilled maintenance workers are needed to keep

Chemical engineer monitors process at chemical plant.



Design engineer, drafter, and model builder examine model of new chemical plant layout.

this equipment in good condition. Pipefitters and boilermakers lay out, install, and repair pipes, vats, and pressure tanks, maintenance machinists make and repair metal parts for machinery, electricians maintain and repair wiring, motors, and other electrical equipment, and instrument repairers install and service instruments and control devices. In some chemical plants, one worker may do several of these jobs Plant workers also are needed to drive trucks, keep inventory of stock and tools, load and unload trucks, ships, and railroad cars, keep the plant and office clean, and do many other kinds of work.

Administrative, Clerical, and Related Occupations. About one out of five industrial chemical workers holds an administrative, clerical, or other nonscientific white-collar job High-level managers generally are trained in chemistry or chemical engineering. These executives decide what products to manufacture, where to build plants, and how to handle the company's finances Executives depend on specialized workers including accountants, sales representatives, lawyers, industrial and public relations workers, market researchers, computer programmers, and personnel and advertising workers Many secretaries, typists, payroll and shipping clerks, and other clerical employees work in offices and plants

(Individual statements elsewhere in the *Handbook* give detailed discussions of many scientific, technical, maintenance, and other occupations found in the industrial chemical industry as well as in other industries)

Training, Other Qualifications, and Advancement

Jobs in the industrial chemical industry require from a few days of on-the-job training to many years of preparation. Some plant workers can learn their jobs in a day or two Scientists, engineers, technicians, and chemical operators, on the other hand, spend several years learning their skills.

Industrial chemical firms generally hire and train inexperienced high school graduates for processing jobs. Equipment operators and other processing workers often start out in a labor pool where they are assigned jobs such as filling barrels or moving materials. Workers may be transferred from the labor pool to fill vacancies in one of the processing departments. Training for processing occupations is done almost entirely on the job under the supervision of an experienced worker. Workers move to jobs requiring greater skills as they gain experience and job openings occur. Thus, a worker may advance from laborer to chemical operator helper, and then to chemical operator. Skilled processing workers are rarely recruited from other plants.

Although many maintenance workers start as helpers and pick up their skills from experienced workers, apprenticeship is the best way to learn a maintenance trade. Apprenticeship programs usually last 3 or 4 years and consist mainly of shop training in their particular jobs Instrument repairers sometimes attend training programs offered by instrument manufacturers. Maintenance workers and trainees are encouraged to take job-related courses at local vocational or technical schools. Their employers may pay part or all of the tuition.

Technicians qualify for their jobs in many ways. Graduates of technical institutes, junior colleges, or vocational technical schools have the best opportunities. Companies also hire students who have completed part of the requirements for a college degree, especially if they have studied mathematics, science, or engineering. High school graduates with courses in chemistry can qualify through on-the-job training and experience. Many technicians receive additional technical school or undergraduate training through company tuition-refund programs.

Laboratory technicians usually start as trainees or assistants, and drafters begin as copyists or tracers. As they gain experience and show ability to work without close supervision, these technicians advance from routine work to more difficult and responsible jobs.

Engineers and scientists must have at least a bachelor's degree in engineering, chemistry, or a related science. Most research jobs, however, require advanced degrees or specialized experience. Many scientists and engineers attend graduate courses at company expense.

Some firms have formal training programs for newly hired scientists and engineers. Before they are assigned to a particular job, these employees work briefly in various departments to learn about the company's overall operation. In other firms, junior scientists and engineers are assigned immediately to a specific job.

Chemists and engineers as well as people with college degrees in business administration, accounting, economics, statistics, marketing, and industrial relations, often advance to administrative jobs Some companies have advanced training programs for new administrative employees Persons with a technical background in chemistry or engineering will have the best opportunities for sales positions.

Secretaries, bookkeepers, and other clerical workers generally have had commercial courses in high school or business school.

Employment Outlook

Employment in the industrial chemical industry is expected to grow more slowly than the average for all industries through the mid-1980's Most job openings will occur from the need to replace experienced workers who retire, die, or transfer to other industries.

However, continued emphasis on research and development is expected to stimulate some growth in the industrial chemical industry, which has far outstripped most other major industries in the development of new products. Some of these products, such as plastics and synthetics, not only have created new markets but also have competed successfully in markets previously dominated by woods, metals, and natural textiles. Chemical products are expected to continue to make advances in these markets. However, higher production costs may cause the growth rate in the production of industrial chemicals to slow down in the future. Firms are expected to pay more for petroleum and natural gas, which are the raw materials for many industrial chemicals. In addition, more stringent air and water quality standards are forcing chemical companies to spend more money for pollution control equipment.

Employment is expected to grow at a slower rate than production because of laborsaving technological developments and the greater use of automatic processing and control equipment. Although the composition of employment in the industry is expected to change, with more administrative and technical workers needed to handle the increasingly complex production processes, most job openings will be for production workers since they are the largest group of employees.

Earnings and Working Conditions

Production workers in the industrial chemical industry have relatively high earnings because a large proportion of them are in skilled jobs. In 1976 they averaged $6.21 an hour, compared with $4.87 an hour for production workers in all industries.

National wage data are not available for individual occupations in the industrial chemicals industry. However, specified in 1976 hourly wages in a few union-management contracts were as follows:

	Hourly rates
Instrument repairers	$4 93–5.30
Laboratory technicians	4.82–7.07
Chemical operators	4 64–6 90
Pipefitters, boilermakers, and sheet-metal workers	4.98–7 95

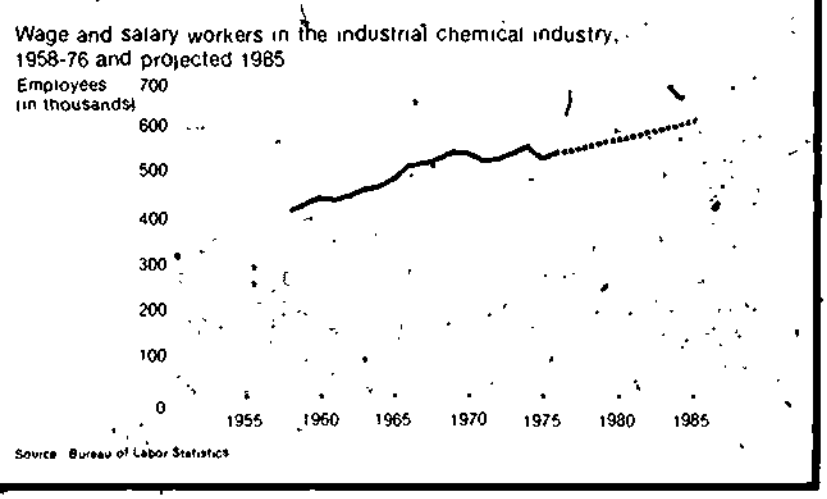
Because chemical plants usually operate around the clock—three shifts a day, 7 days a week—processing workers often work the second or third shift, usually for extra pay. Shift assignments are usually rotated, so an individual may work days 1 week and nights the next. Maintenance workers usually work only the day shift.

Most industrial chemical jobs, except those for laborers or material handlers, are not strenuous. Equipment operators are on their feet most of the time. Some workers must climb stairs or ladders to considerable heights, or work outdoors in all kinds of weather. Workers may be exposed to dust, disagreeable odors, or high temperatures, although many plants have ventilating or air-conditioning systems.

Many chemicals are dangerous to touch or breathe. However, the industrial chemical industry has one of the better safety records in manufacturing. Protective clothing, eyeglasses, showers, eye baths near hazardous work stations, and other safety measures help prevent serious injuries.

Many production workers in the industrial chemical industry belong to labor unions, including the Inter-

Continued long-term growth is expected in the industrial chemical industry, despite some sensitivity to the business cycle



national Chemical Workers Union, Oil, Chemical, and Atomic Workers International Union; and the United Steelworkers of America.

Sources of Additional Information

Further information on careers in the industry may be obtained from employment offices of industrial chemical companies, locals of the unions mentioned above, and from:

American Chemical Society, 1155 16th St NW, Washington, D.C. 20036

Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave. NW, Washington, D.C. 20009

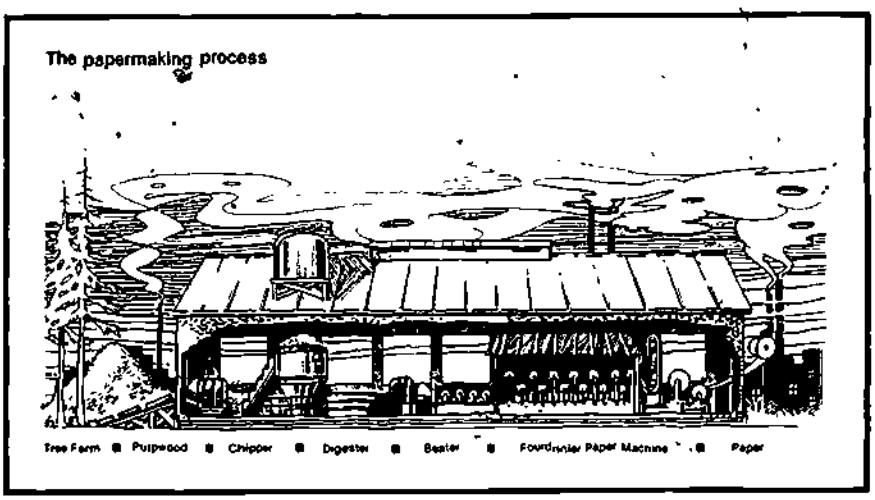
OCCUPATIONS IN THE PAPER AND ALLIED PRODUCTS INDUSTRIES

In 1976, the paper and allied products industry employed about 676,000 people to produce many different kinds of paper and paperboard products. The industry employs workers in occupations ranging from unskilled to highly specialized technical and professional jobs, many found only in the paper industry.

Nature and Location of the Industry

The paper industry is highly mechanized. Pulp, paper, and many finished paper products are manufactured by machines—some as long as a football field—in a series of nearly automatic operations that require very little handling of materials by workers. Manufacturing plants in the paper industry are engaged in one or more of three different operations: The production of pulp (the basic ingredient of paper) from wood, reused fibers, or other raw materials; the manufacture of paper or paperboard (thick paper) from pulp, or the conversion of rolls or sheets of paper or paperboard into finished products, such as tissue paper, envelopes, and boxes.

The largest group of employees in the industry work in mills that produce pulp, paper, or paperboard. The next largest group works in plants that make boxes and containers; and the remainder work in plants that make a variety of other paper products.



About four-fifths of the industry's employees work in factories that employ 100 workers or more.

Workers in this industry are located throughout the country, although about half are employed in eight States: New York, Pennsylvania, Illinois, Ohio, Wisconsin, Massachusetts, California, and New Jersey.

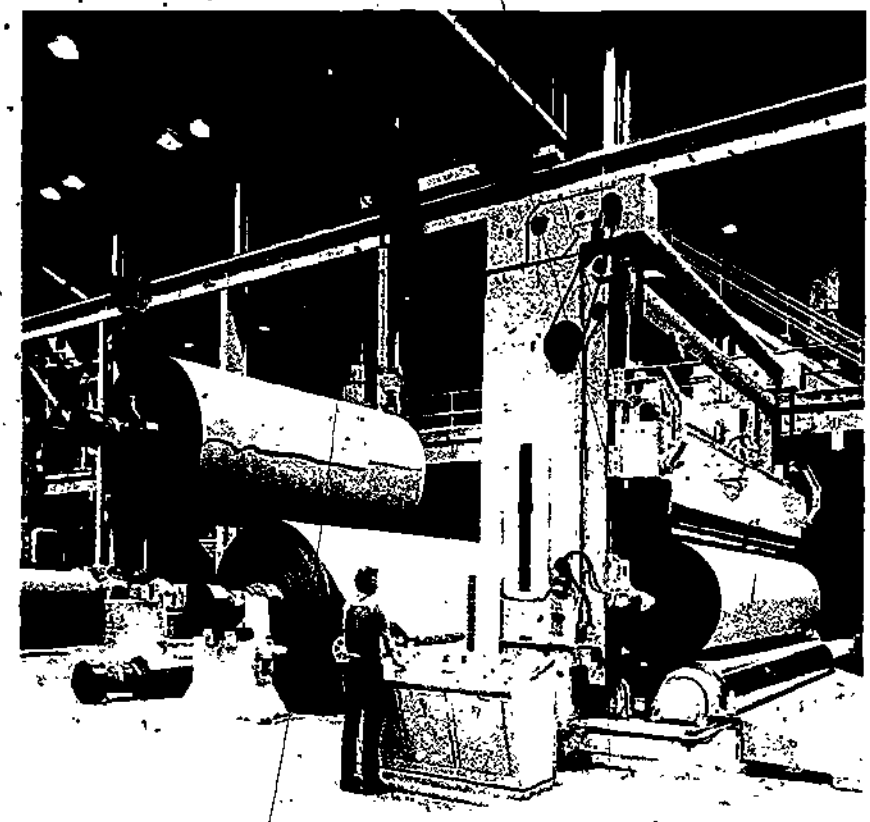
Occupations in the Industry

Employees in the paper industry work in a variety of occupations requiring a broad range of training and skills. Many workers operate and control specialized papermaking, finishing, and converting machines. Some workers install and repair papermaking machinery. Truck drivers make deliveries, and other workers load and unload trucks, railroad cars, and ships.

The industry employs many workers in clerical, sales, and administrative occupations. For example, it employs purchasing agents, personnel managers, sales representatives, office clerks, stenographers, bookkeepers, and business machine operators. Also, because of the complex processes and equipment used, the industry employs professional and technical workers, including chemical and mechanical engineers, chemists, laboratory technicians, and pulp and paper testers. (Detailed discussions of professional, technical, and mechanical occupations, found not only in the paper industry but in other industries, are given elsewhere in the *Handbook* in sections covering individual occupations.)

Production Jobs. In 1976, more than three-fourths of all employees in the industry worked in production jobs. The simplified description of papermaking occupations and processes that follows applies to a plant which combines the production of pulp, paper, and finished paper products into one continuous operation. (See accompanying chart.)

After trees are cut down, loggers will saw off the limbs and saw the trunk into logs. The logs are then transported to the pulp mill where the bark is removed. One machine used for this operation is a large



The paper industry is highly mechanized.

revolving cylinder known as a "drum barker." Logs are placed on a conveyor belt and fed into this machine by a semiskilled worker called a *barker operator* (D.O.T. 533.782). The machine cleans bark from the logs by tumbling them against each other and also against the rough inner surface of the drum. Next, pulp fibers in the logs are separated from other substances by a chemical or mechanical process, or both, depending on the type of wood used and the grade of paper desired.

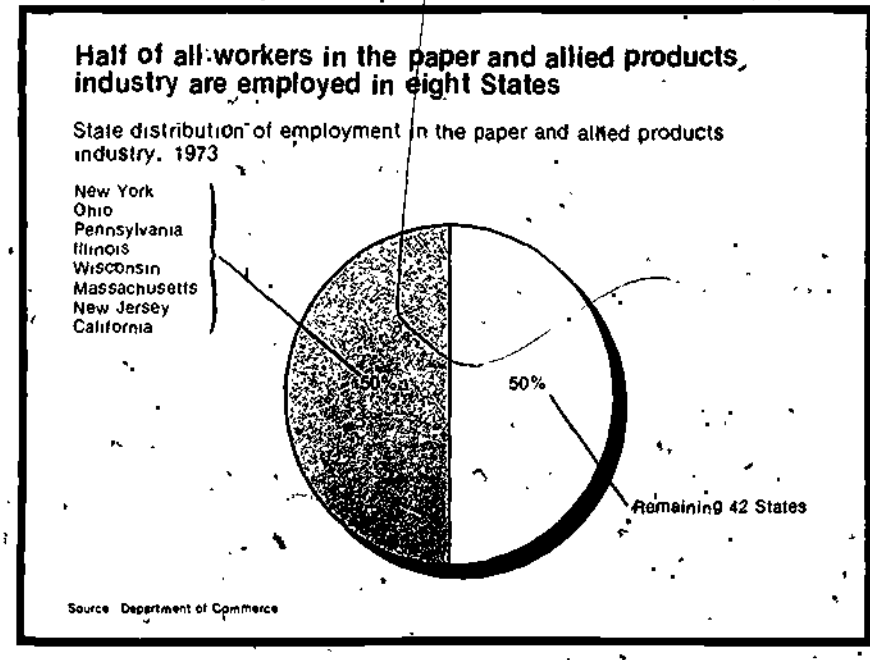
In the mechanical process, pulpwood is held against a fast-revolving grindstone that separates the fibers. In the more commonly used chemical process, pulpwood is carried on conveyor belts to a chipper machine operated by a *chipper* (D.O.T. 668.885). The machine cuts the pulpwood into chips about the size of a quarter.

In recent years, a larger number of mobile harvesters and chippers have been used to chip whole trees or logs at the orginal harvest site, thereby reducing transportation costs and the amount of wood not utilized.

After the logs have been converted to wood chips, they are "cooked" with chemicals under high temperature and pressure in a "digester," a kettlelike vat several stories high. Digesters are operated by skilled workers called *digester operators* (D.O.T. 532.782), who determine the amount of chemicals to be used and the cooking temperature and pressure. They also direct the loading of the digester with wood chips and chemicals. By checking an instrument panel, digester operators make certain that proper conditions are being maintained. When the pulp fibers are removed from the digester, they are washed to remove chemicals, partially cooked chips, and other impurities. These fibers, called pulp, resemble wet, brown cotton.

Many modern plants today are making greater use of continuous digesters (equipment that produces pulp continuously rather than in separate batches). Continuous digesters make it practical to use sawdust in pulpmaking, and eliminate the manual starting and stopping of each batch of pulp.

To turn pulp into paper, the pulp is mixed thoroughly with water and further refined in machines operated by skilled workers called *beater engineers* (D.O.T. 530.782). The kind and amount of chemicals and dyes they use and the length of time they "beat" the solution determine the color and strength of the paper.



The pulp solution, now more than 99 percent water, is turned into paper or paperboard by machines that are among the largest in American industry. The machines are of two general types. One is the Fourdrinier machine, by far the most commonly used; the other is the cylinder machine used to make particular types of paper, such as building and container board. In the Fourdrinier, the pulp solution pours into a continuously moving and vibrating belt of fine wire screen. As the water drains, millions of pulp fibers adhere to one another, forming a thin wet sheet of paper. After passing through presses that squeeze out more water, the newly formed paper passes through the dryer section of the papermaking machine to evaporate remaining water.

The quality of the paper produced largely depends on the skills of *paper machine operators* (D.O.T. 539.782), who control the "wet-end" of the papermaking machine to form paper of specified thickness, width, and physical strength. They check control-panel instruments to make sure the flow of pulp and the speed of the machine are coordinated. Paper machine operators also determine whether the paper meets required specifications by interpreting laboratory tests or, in some instances, by visually checking or feeling the paper. They supervise the less skilled workers of the machine crew and, with their help, keep the paper moving smoothly through the machine.

Many modern papermills have papermaking machines that use computers and advanced instrumentation to help the operator control the quality of the paper. For example, beta-ray sensors measure the weight of the paper and electromagnetic sensors measure the thickness. Measurements from these devices are put into a computer that compares them to programmed specifications. The computer then adjusts the papermaking machine's operations to eliminate any differences. Computer process control also has brought about changes in job duties for some operator positions. Generally this has involved a reduction in manual manipulation of control devices and an increase in monitoring functions. For example, the computer sets production variables such as temperature, pressure, and flow rates whereas, before computer control, they were set by the machine operator.

Backtenders (D.O.T. 532.885), who are supervised by paper machine operators, control the pressure and temperature of machinery that dries and finishes the paper and gives it the correct thickness. Backtenders inspect the paper for imperfections and make sure that it is being wound tightly and uniformly into rolls. They also adjust the machinery that cuts the rolls into smaller rolls and, with the help of assistants, may weigh and wrap the rolls for shipment.

Papermills that produce a fine grade of paper for books, magazines, or stationary usually have finishing departments. Most workers in these departments are either semiskilled or unskilled. One semiskilled worker, the *supercalender operator* (D.O.T. 534.782), aided by several helpers and by mechanical handling equipment, places huge rolls of paper onto a machine that gives the paper a smooth and glossy finish. The supercalender operator also inspects the finished paper to make sure that specifications have been met. Another semiskilled worker, the *paper sorter and counter* (D.O.T. 649.687), inspects sheets of paper for tears, dirt spots, and wrinkles; counts them; and may fill customer orders.

In converting plants, machines operated by semiskilled or skilled workers convert paper and paperboard into envelopes, napkins, corrugated shipping containers, and other paper products. Occupations in converting plants differ widely, depending largely on the product being manufactured. An example of a semiskilled worker is the *envelope machine operator* (D.O.T. 641.885), who feeds and tends an automatic machine that makes envelopes from either rolls of paper or prepared envelope blanks. One of the few skilled workers in a converting plant is the *printer-slotter operator* (D.O.T. 651.782) who controls a machine that cuts and creases paperboard sheets and prints designs or lettering on them.

Converting plants employ thousands of workers to print designs and lettering on bags, labels, wallpaper, and other paper products. Among these are compositors, who set type, and press operators who prepare and operate printing presses

Maintenance Jobs. The paper industry employs many skilled maintenance workers to care for its complex machinery and electrical equipment. *Millwrights* install and repair machinery. They also take apart and reassemble machines when they are moved about the plant. *Instrument repairers* install and service instruments that measure and control the flow of pulp, paper, water, steam, and chemical additives.

Other important maintenance employees include *electricians*, who repair wiring, motors, control panels, and switches; *maintenance machinists*, who make replacement parts for mechanical equipment, and *pipefitters*, who lay out, install, and repair pipes.

Stationary engineers are employed to operate and maintain powerplants, steam engines, boilers, air compressors, and turbines.

Professional and Technical Occupations. The complexity of pulp and paper manufacturing requires thousands of workers who have engineering, chemical, or other technical training. Approximately 16,000 scientists and engineers and 13,000 technicians were employed by the paper industry in 1976.

Many chemists are employed to control the quality of the product by supervising the testing of pulp and paper. In research laboratories, chemists study the influence of various chemicals on pulp and paper. In addition, some chemists and engineers are employed as sales representatives, supervisors of plant workers, or as administrators in positions which require technical knowledge.

Chemical and *mechanical engineers* transform new pulp and papermaking techniques into practical production methods. Some chemical engineers supervise the production process. *Electrical engineers* supervise the operation of power-generating and distributing equipment and instruments.

Packaging engineers design containers and packages and supervise their production. A few box manufacturers also employ artists who develop lettering, designs, and colors for containers.

Foresters manage large areas of timberland and assist in the woodbuying operations of pulp and paper companies. They map forest areas, plan and supervise the harvesting, and seed or plant new trees to assure continuous production of timber.

Systems analysts and *computer programmers* are becoming increasingly important to this industry due to the greater use of computerized controls in the production process. They also analyze business and production problems and convert them to a form suitable for solution by computer.

Frequent tests are performed during the manufacture of pulp or paper to determine whether size, weight, strength, color, and other properties meet standards. Some testing is done by machine operators, but in many mills *testing technicians* are employed. These technicians, who have job titles such as laboratory technician, pulp tester, and chemical analyst, also assist engineers and chemists in research and development activities.

Administrative, Clerical and Related Occupations The paper industry employs many administrative, clerical, and other office personnel. Executives plan and administer company policy. To work effectively, executives require information from a wide variety of personnel, including accountants, sales representatives, lawyers, and personnel in industrial relations, transportation, market research, and other activities. Bookkeepers, secretaries, shipping clerks, and other clerical workers keep records of personnel, payroll, inventories, sales, shipments, and plant maintenance.

Training, Other Qualifications, and Advancement

Paper and pulp companies generally hire and train inexperienced workers for production and maintenance occupations. Many companies prefer to hire high school graduates. Inexperienced workers usually start as laborers or helpers and advance along fairly well-defined paths to more skilled jobs.

Some large plants have formal apprenticeship programs for maintenance workers. Under these programs, which usually last 3 to 4 years, people are trained for jobs such as machinist, electrician, millwright, and pipefitter. Generally, an applicant is given a physical examination, mechanical aptitude tests, and similar qualifying tests. Apprenticeship includes both on-the-job training and classroom instruction related to the occupation. The machinist apprentice, for example, receives classroom instructions in mathematics, blueprint reading, and shop theory.

In newer mills, many experienced maintenance workers are being retrained to become multi or four-skilled craftworkers. The workers are given 18 months to become competent in each individual craft or a total of 4 1/2 years. For example, a pipefitter would learn the skills of a millwright, machinist, and an electrician.

A bachelor's degree is usually the minimum educational requirement for scientists, engineers, foresters, and other professional occupations. For research work, persons having advanced degrees are preferred. Many engineers and chemists (called *process engineers* and *paper chemists*) have specialized training in paper technology. Many companies have summer jobs for college students specializing in papermaking, and upon graduation frequently hire them on a permanent basis. Some associations, colleges and individual companies offer scholarships in pulp and paper making technology.

Some companies have formal training programs for college graduates with engineering or scientific backgrounds. These employees may work for brief periods in various parts of the plant to gain a broad knowledge of pulp and paper manufacturing before being assigned to a particular department. Other firms immediately assign junior chemists or engineers to a specific research, operation, or maintenance unit.

Generally, no specialized education is required for laboratory assistants, testing technicians, or other kinds of technicians. Some employers, however, prefer to hire technical institute or junior college graduates. Beginning technicians start in routine jobs and advance to positions of greater responsibility after they acquire experience and can work with minimum supervision.

Administrative positions usually are filled by people who have college degrees in business administration, marketing, accounting, industrial relations, or other specialized business fields. A knowledge of paper technology is helpful for administrators and sales occupations. This is true especially for sales representatives who give customers technical assistance. Most pulp and paper companies employ clerks, bookkeepers, stenographers, and typists who have had commercial courses in high school or business school.

For production workers, promotion generally is limited to more skilled jobs within a "work area," which may be a department, section, or an operation on one type of machine. For example, a person may start as a utility person and advance to backtender and finally to machine operator. These promotions may take years, depending on the availability of jobs. Experience gained within a work area usually is not transferable, unskilled or semiskilled workers who transfer to jobs outside their usual work area or to other plants usually must start in entry jobs.

Many plant supervisors are former production workers. In some plants, qualified workers may be promoted directly to supervisory positions. In others, workers are given additional training before they are eligible for promotion. This training often is continued after the worker is promoted—through conferences, special plant training sessions, and courses at universities or trade schools. Most firms provide some financial assistance for employees who take courses outside the plant.

Employment Outlook

Employment in the paper and allied products industry is expected to increase more slowly than the average for all industries through the

mid-1980's. Although a significant number of job openings are expected due to growth, most openings will stem from the need to replace workers who retire, die, or leave their jobs for other reasons. The number of job openings may fluctuate from year to year, however, because the demand for paper and paper products is sensitive to changes in economic conditions.

Paper production is expected to increase over the long run as population and business activity grow and new uses for paper are developed. Employment will grow at a slower rate than production, however, because of the greater use of laborsaving machinery. Most of the employment growth will occur in plants that make finished products such as napkins, envelopes, boxes, and wrapping paper. These plants are not as suited for laborsaving machinery as plants that produce pulp and unfinished paper products.

Occupational groups within the industry are expected to grow at different rates. The number of engineers, scientists, technicians, and maintenance workers is expected to increase faster than other occupational groups in the industry. More scientific and technical personnel will be needed as research and development activities expand, and more maintenance workers will be required to service the more complex machinery. Employment of administrative and clerical workers also is expected to rise at a faster pace than total employment. On the other hand, the number of production workers may decline slightly as more laborsaving machinery is introduced. Nevertheless, replacement needs will create many job openings for production workers.

Earnings and Working Conditions

Production workers in the paper industry had average earnings of $5.43 an hour in 1976. In the same year, production workers in private industry, except farming, averaged $4.87 an hour.

The following tabulation, based on information from a number of union-management contracts in the paper industry, illustrates the approximate range of hourly wage rates for selected production and maintenance occupations in 1976. Local rates within these ranges depend on geographic location, type and size of mill, kinds of machines used, and other factors.

Most pulp and paper plants operate around the clock—three shifts a day, 7 days a week. Production workers can expect to work on evening or night shifts from time to time. Maintenance workers usually are employed on the regular day shift. Multi-craft maintenance mechanics generally earn about $1.50 an hour more than a single-craft mechanic.

In most plants the standard workweek is 40 hours; in a few it is 36 hours or less. Workers normally have year-round employment because paper production is not subject to seasonal variation.

Most pulp and papermaking jobs do not require strenuous physical effort. However, some employees work in hot, humid, and noisy areas. They also may be exposed to disagreeable odors from chemicals in the papermaking process. The rate of injury in this industry has been about the same as the rate for all manufacturing.

A majority of the production workers are members of trade unions. The largest union in the industry is the United Paperworkers International Union. Many other workers in the Western States are represented by the Association of Western Pulp and Paper Workers. Many printing workers belong to the International Printing and Graphic Communications Union. Some maintenance and craft workers belong to various craft unions.

Sources of Additional Information

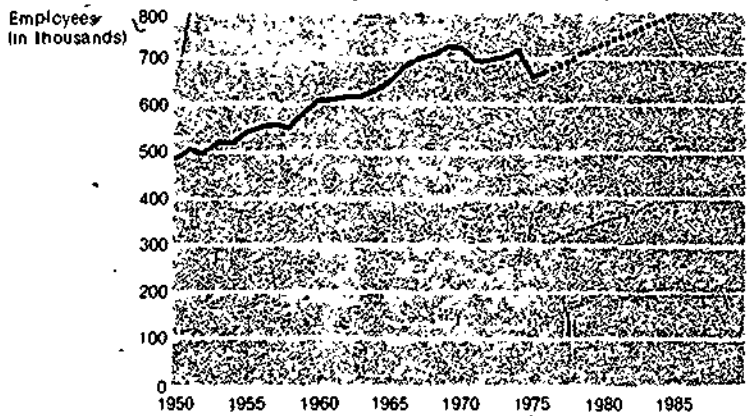
Further information about job opportunities in this industry is available from local offices of the State employment service and from:

American Paper Institute, 260 Madison Ave., New York, N.Y. 10016.

Fibre Box Association, 224 S. Michigan Ave., Chicago, Ill. 60604.

Employment in paper manufacturing is expected to continue growing over the long run.

Wage and salary workers in paper and allied products manufacturing, 1950-76 and projected 1985



Source: Bureau of Labor Statistics

	Hourly rate ranges
Production occupations:	
Paper machine operator	$5.34–10.41
Backtender	4.87– 9.91
Head stock preparer (beater engineer)	4.93– 7.01
Digester operator (cook)	5.07– 7.30
Supercalendar operator	5.18– 6.36
Barker operator, drum	4.69– 6.80
Chipper	4.40– 6.70
Maintenance occupations:	
Pipefitter	5.58– 7.76
Electrician	5.74– 7.76
Machinist	5.58– 7.76

A list of schools offering courses on paper technology is available from:

American Paper Institute, 260 Madison Ave., New York, N.Y. 10016.

For information on job opportunities for paper and paper products sales representatives, write to:

National Paper Trade Association, Inc., 420 Lexington Ave., New York, N.Y. 10017.

OCCUPATIONS IN THE PETROLEUM REFINING INDUSTRY

The petroleum refining industry forms the link between crude oil production and the distribution and consumption of petroleum products. Products refined from crude oil supply the fuels and lubricants used for all modes of transportation, for heat in homes, factories, and other structures, and for fuel for the generation of over one-third of our electric power. In addition, basic petroleum compounds are used to manufacture hundreds of everyday products such as synthetic rubber, fertilizers, and plastics.

In 1976 about 160,000 workers, who had a wide range of educational backgrounds and skills, were employed in the petroleum refining industry. This industry covers occupations and activities involved in refining oil. Occupations in petroleum and natural gas production and processing are discussed in a separate chapter elsewhere in the *Handbook*.

Nature and Location of the Industry

A modern refinery is a complicated plant made up of tanks and towers connected by a maze of pipes and valves. From the time crude oil enters the refinery to the shipment of finished products, the production flow is almost continuous. Operators use instruments including computers to measure and regulate the flow, volume, temperature, and pressure of liquids and gases going through the equipment. Manual handling of materials has been virtually eliminated.

Petroleum refining consists of heating crude oil as it flows through a series of pipes in a furnace. The vapors from the heated oil pass into a tower where the various "fractions," or parts, of the oil are condensed. The heaviest parts (for example, heavy fuel oils and asphalt) are drawn off along the bottom of the tower where temperatures are highest, lighter parts (jet fuel and diesel fuel) are drawn off along the middle of the tower, and the lightest (gasoline and gases) are taken off at the top where temperatures are lowest. Since this process does not produce a sufficient quantity of some products, such as gasoline, further processing by more complicated methods combines or modifies products obtained through fractionating to increase the yield of some products. Treating units are used to remove water, sulfur compounds, and other impurities.

About 280 refineries were in operation in 1976. They ranged in size from plants with fewer than ten employees to those with several thousand. Although many States have refineries, about 85 percent of the workers were employed in 10 States: Texas, California, Pennsylvania, Illinois, Louisiana, Oklahoma, Ohio, New York, New Jersey, and Indiana. Refineries usually are located near oilfields, industrial centers, or deep-water ports where tankers can dock.

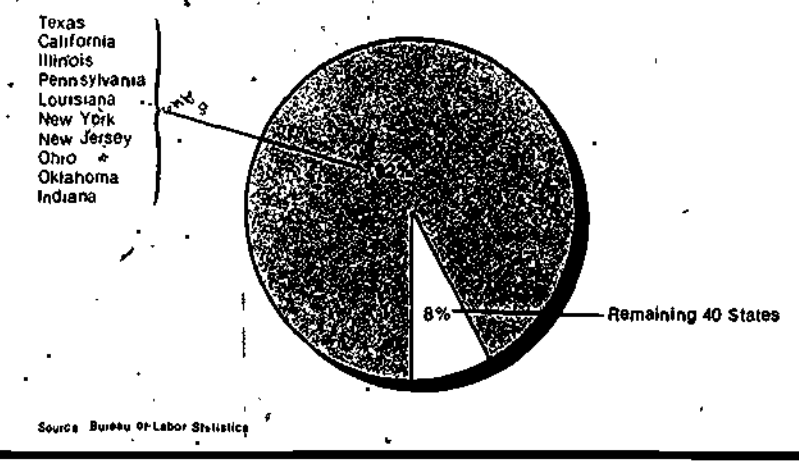
Occupations in the Industry

About 1 out of every 2 workers in a refinery is involved in the operation (as opposed to maintenance) of the plant. A key worker in converting crude oil into usable products is the *refinery operator* (D.O.T. 542.280), or chief operator, who is responsible for one or more processing units. The refinery operator, with help from assistant operators, makes adjustments for changes in temperature, pressure, and oil flow. In modern refineries, operators monitor instruments on panels that show the entire operation of all processing units in the refinery. They also patrol units to check their operating condition.

Other plantworkers may include *still pump operators* (D.O.T. 549.782), also known as pumpers, and their *helpers* (D.O.T. 549.884), who maintain and operate pumps that control all production throughout the refinery, and *treaters* (D.O.T. 549.782), who operate equipment to

Over 90 percent of all workers in the petroleum refining industry are employed in ten States

State distribution of workers in the petroleum refining industry, 1974



Source: Bureau of Labor Statistics

remove impurities from gasoline, oil, and other products In automated plants, computers may do the work of pumpers and treaters. Operators monitor the computers to spot potential problem areas, and may make routine checks of the refinery to make sure that valves are operating properly.

Many refineries employ large numbers of maintenance workers to repair, rebuild, replace, and clean equipment. In other plants, some maintenance work is contracted to companies outside the petroleum industry. Many maintenance workers are needed because high heat, pressure, and corrosion quickly wear out the complex refining equipment. Occupations involved in maintenance include skilled boilermakers, electricians, carpenters, instrument repairers, machinists, pipefitters, sheetmetal workers, and welders There also are helpers and apprentices in these trades. Some skilled workers have a primary skill in one craft and also the ability to handle closely related crafts. For example, a pipefitter also may be a boilermaker and a welder. Maintenance workers who have such combined jobs are sometimes called refinery mechanics

Plantworkers who do not operate, monitor, or maintain equipment do many other tasks Some workers drive delivery trucks; some load and unload materials on trucks, trains, or ships, and others keep stock and tool inventory records. The industry also employs service workers such as guards and janitors.

About 12 percent of the workers in petroleum refining are scientists, engineers, and technicians. Among these are chemists, chemical engineers, mechanical engineers, environmental engineers, laboratory technicians, and drafters. Chemists and laboratory technicians control the quality of petroleum products by making tests and analyses to determine chemical and physical properties. Some chemists and chemical engineers develop and improve products and processes. Laboratory technicians assist chemists in research projects or do routine testing and sample taking. Some engineers design chemical processing equipment and plant layout, and others

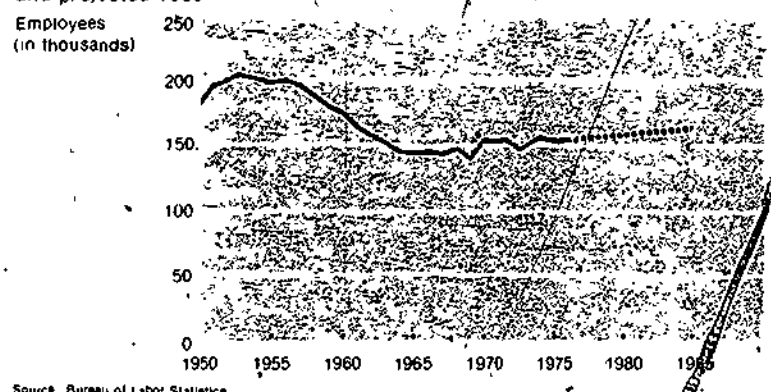
Operator observes refinery controls.

supervise refining processes. Environmental engineers and technicians supervise and improve treatment and disposal of refinery waste waters and gases. Drafters prepare plans and drawings needed in refinery construction and maintenance.

Refining companies employ many administrative, clerical, and other white-collar personnel. Administrative workers include managers, accountants, purchasing agents, lawyers, computer programmers, computer analysts, and personnel

Employment in petroleum refining is expected to show little change through the mid-1980's due to productivity improvements

Wage and salary workers in the petroleum refining industry, 1950-76 and projected 1985



Source: Bureau of Labor Statistics

and training specialists. Typists, secretaries, bookkeepers, keypunch operators, and business machine operators assist administrative workers. (Detailed discussions of professional, technical, mechanical, and other occupations found not only in petroleum refining but also in other industries are presented elsewhere in the *Handbook*.)

Training, Other Qualifications, and Advancement

Employers prefer to hire applicants who are high school graduates. Aptitude testing and interviewing frequently are used in selecting applicants for plant jobs. Inexperienced plantworkers usually begin as aides in a labor pool; they may move materials, pack cartons, fill barrels, or do maintenance work. They may be transferred either to the operating department or the maintenance department when a vacancy occurs.

Workers newly assigned to an operating department learn to operate equipment under the guidance of experienced operators. Formal training courses frequently are given in plant operation.

A supervisor trains inexperienced workers in maintenance skills. Some refineries give classroom instruction related to particular work. After 3 or 4 years, a person may advance from helper to skilled craft worker in one of the maintenance crafts. Some large refineries train workers in several crafts. For example, a qualified instrument repairer may be given electrician or machinist training.

For scientists and engineers, a bachelor's degree in an appropriate field usually is the minimum educational requirement. Advanced degrees are preferred for research work.

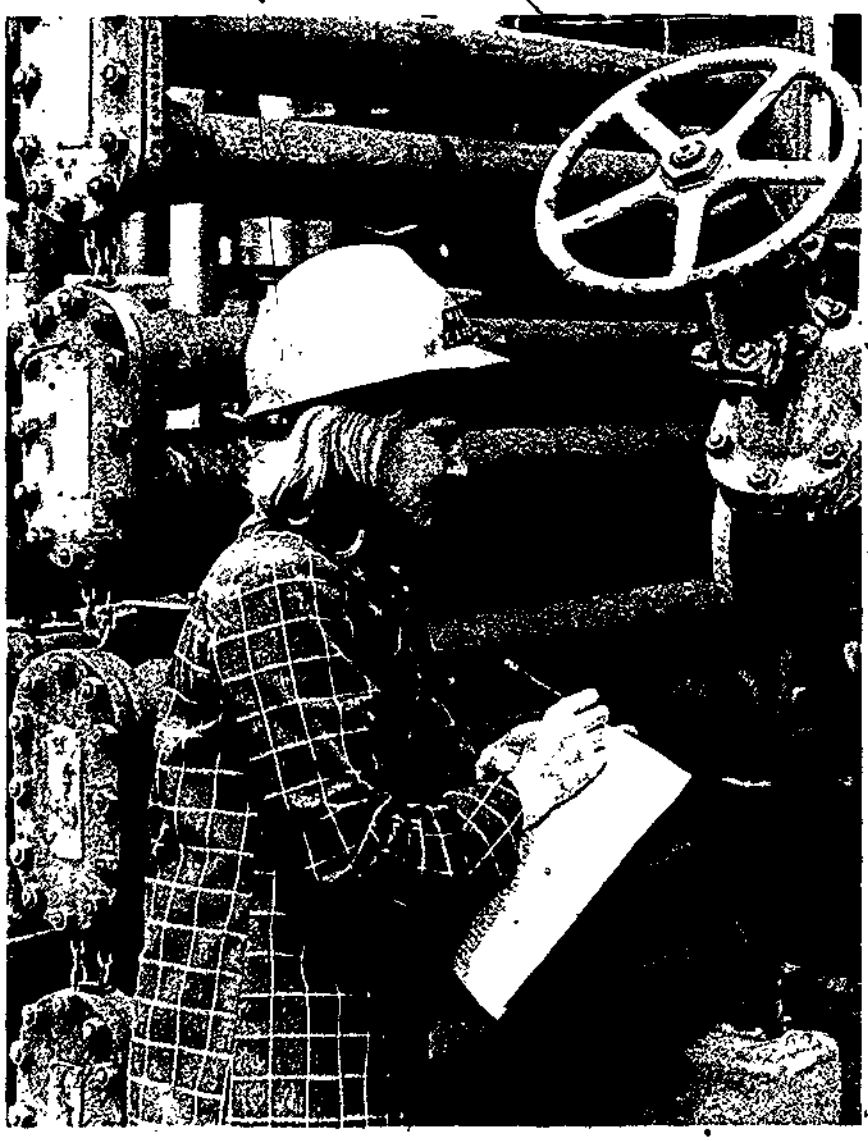
For most laboratory assistant jobs, 2-year technical school training is required. Laboratory assistants begin in routine jobs and advance to positions of greater responsibility as they acquire experience and learn to work without close supervision. Inexperienced drafters begin as copyists or tracers and can advance to more skilled drafting jobs.

Administrative positions generally are filled by people who have college degrees in science and engineering, accounting, business, industrial relations, or other specialized fields. For positions as clerks, bookkeepers, secretaries, and typists, most refineries employ persons who have had commercial courses in high school or business school. For occupations associated with computers, educational requirements range from a high school level for keypunch operators to a college degree in the physical science field for analysts.

Employment Outlook

Employment in petroleum refining is expected to show little change through the mid-1980's. Refinery output is expected to increase to meet the Nation's growing demand for petroleum products, but automated, computerized plants, increased refining capacity, and improved refining techniques should make it possible for the industry to increase production without increasing employment significantly. Nevertheless, thousands of job openings will result from the need to replace workers who retire, die, or transfer to other occupations.

Most jobs will be for operators, maintenance workers, administrators, and technicians. More maintenance workers, such as electricians, pipefitters, and instrument repairers, will be needed to take care of the



Most refinery jobs require only moderate physical effort.

increasing amount of automated equipment and complex control instruments.

Earnings and Working Conditions

Refinery workers are among the highest paid employees in manufacturing. In 1976 production workers in petroleum refining averaged $7.72 an hour, compared with an average of $4.83 an hour for production workers in manufacturing industries as a whole.

Because petroleum is refined around the clock, operators may be assigned to any one of the three shifts, or they may be rotated on various shifts. Some operators work weekends and get days off during the week. Employees usually receive additional pay for shift work. Most maintenance workers are on duty during the day.

Most refinery jobs require only moderate physical effort. A few workers, however, have to open and close heavy valves and climb stairs and ladders to considerable heights. Others may work in hot places or may be exposed to unpleasant odors.

Many refinery workers are union members and belong to the Oil, Chemical and Atomic Workers International Union. Some refinery workers are members of AFL-CIO craft unions or of various independent unions.

Sources of Additional Information

More information on job opportunities in the petroleum refining industry may be obtained from the personnel offices of individual oil companies. General information on jobs in the industry is available from:

National Petroleum Refiners Association, Suite 802, 1725 DeSales St., NW., Washington, D.C. 20036.

U.S. GOVERNMENT PRINTING OFFICE : 1977 O—248-025

What to Look For in this Reprint

To make the *Occupational Outlook Handbook* easier to use, each occupation or industry follows the same outline. Separate sections describe basic elements, such as work on the job, education and training needed, and salaries or wages. Some sections will be more useful if you know how to interpret the information as explained below.

The TRAINING, OTHER QUALIFICATIONS, AND ADVANCEMENT section indicates the preferred way to enter each occupation and alternative ways to obtain training. Read this section carefully because early planning makes many fields easier to enter. Also, the level at which you enter and the speed with which you advance often depend on your training. If you are a student, you may want to consider taking those courses thought useful for the occupations which interest you.

Besides training, you may need a State license or certificate. The training section indicates which occupations generally require these. Check requirements in the State where you plan to work because State regulations vary.

Whether an occupation suits your personality is another important area to explore. For some, you may have to make responsible decisions in a highly competitive atmosphere. For others, you may do only routine tasks under close supervision. To work successfully in a particular job, you may have to do one or more of the following:

- motivate others
- direct and supervise others
- work with all types of people
- work with things—you need good coordination and manual dexterity
- work independently—you need initiative and self-discipline
- work as part of a team
- work with details, perhaps numbers or laboratory reports
- help people
- use creative talents and ideas
- work in a confined area
- do physically hard or dangerous work
- work outside in all types of weather

A counselor can help you find out more about your interests and abilities so you can judge whether a job's characteristics suit you.

The EMPLOYMENT OUTLOOK section tells whether or not the job market is likely to be favorable. Usually an occupation's expected growth is compared to the average projected growth rate for all occupations (20.1 percent between 1976 and 1985). The following phrases are used:

Much faster	50% or more
Faster	25.0 to 49.9%
About as fast	15.0 to 24.9%
Slower	4.0 to 14.9%
Little change	3.9 to -3.9%
Decline	-4.0% or more

Generally, job opportunities are favorable if employment is growing at least as fast as for the economy as a whole.

But, you would have to know the number of people competing with you to be sure of your prospects. Unfortunately, this supply information is lacking for most occupations.

There are exceptions, however, especially among professional occupations. Nearly everyone who earns a medical degree, for example, becomes a practicing physician. When the number of people pursuing relevant types of education and training and then entering the field can be compared with the demand, the outlook section indicates the supply/demand relationship as follows:

Excellent	Demand much greater than supply
Very good	Demand greater than supply
Good or favorable	Rough balance between demand and supply
May face competition	Likelihood of more supply than demand
Keen competition	Supply greater than demand

Competition or few job openings should not stop you from pursuing a career that matches your aptitudes and interests. Even small or overcrowded occupations provide some jobs. So do those in which employment is growing very slowly or declining.

Growth in an occupation is not the only source of job openings because the number of openings from turnover can be substantial in large occupations. In fact, replacement needs are expected to create 70 percent of all openings between 1976 and 1985.

Finally, job prospects in your area may differ from those in the Nation as a whole. Your State employment service can furnish local information.

The EARNINGS section tells what workers were earning in 1976.

Which jobs pay the most is a hard question to answer because good information is available for only one type of earnings—wages and salaries—and not even this for all occupations. Although 9 out of 10 workers receive this form of income, many earn extra money by working overtime, night shifts, or irregular schedules. In some occupations, workers also receive tips or commissions based on sales or service. Some factory workers are paid a piece rate—an extra payment for each item they make.

The remaining 10 percent of all workers—the self-employed—includes people in many occupations—physicians, barbers, writers, and farmers, for example. Earnings for self-employed workers even in the same occupation differ widely because much depends on whether one is just starting out or has an established business.

Most wage and salary workers receive fringe benefits, such as paid vacations, holidays, and sick leave.

Workers also receive income in goods and services (payment in kind). Sales workers in department stores, for example, often receive discounts on merchandise.

Despite difficulties in determining exactly what people earn on the job, the Earnings section does compare occupational earnings by indicating whether a certain job pays more or less than the average for all nonsupervisors in private industry, excluding farming.

Each occupation has many pay levels. Beginners almost always earn less than workers who have been on the job for some time. Earnings also vary by geographic location but cities that offer the highest earnings often are those where living costs are most expensive.